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Breeding Behaviour and Diet of a Family of Barking Owls *Ninox connivens* in South-eastern Queensland

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Summary

The breeding behaviour and diet of the Barking Owl *Ninox connivens* were investigated in coastal south-eastern Queensland, by observation and by analysis of pellets and prey remains from beneath the nests and roost-sites of one Owl family in spring 2002, 2003 and 2004. The Owls raised four fledglings: two in 2002 and two in 2004, in a different nest, after failure in 2003. Aspects of their nest-sites, roost-sites and behaviour are described. The female roosted in the nest-hollow until the third week of the nestling period, which lasted ~36 days. The Owls' diet consisted of 25% mammals, 10% birds and 65% arthropods by number, and 74% mammals (mostly gliders *Petaurus*, 71%), 24% birds and 1% arthropods by biomass. There was some inter-year difference in the relative contribution of mammals and birds, with earlier laying by the Owls when mammalian prey predominated and later laying when avian prey predominated. Mammals may be the more rewarding prey, enabling female Owls to reach breeding condition early in the season, with subsequent benefits for early-fledged offspring.

Introduction

The Barking Owl *Ninox connivens* is a medium-sized (male ~700 g, female ~600 g) hawk-owl distributed from the Moluccas and New Guinea to tropical and subtropical Australia (i.e. a Torresian species), extending south to the temperate zone in eastern and south-western Australia (Higgins 1999). The Owl's breeding and non-breeding diet has been studied at several sites in south-eastern Australia, mainly in the temperate zone, with little quantification for the subtropics (Higgins 1999 and references therein; Debus 2001; Debus & Rose 2003; Debus *et al.* 2005). Pending the completion and publication of several ecological studies in progress, also in temperate south-eastern Australia, the nominate subspecies *N.c. connivens* is one of the lesser known and perhaps most threatened forest or woodland owls in Australia (Taylor *et al.* 2002a,b). The Owl's breeding behaviour (summarised by Higgins 1999, mainly from captive birds) is little known, with some casual observations on wild birds obtained recently (Debus *et al.* 2005).

This paper describes the breeding behaviour and diet of a pair of Barking Owls and young in subtropical coastal Queensland over three breeding seasons. It continues the study of Hodgon (1996), by reporting on the same Owl territory.

Study area and methods

The study site was Cordalba State Forest 55 km south-south-west of Bundaberg, Queensland (24°53'S, 152°22'E), previously described by Hodgon (1996). The forest is managed for timber, with episodes of logging taking place.

In 2002–2004 the Barking Owls were monitored through parts of the breeding cycle by CPB. In 2002 the nesting area was visited casually on several days in November, with additional observations earlier in the cycle by C. Moller. In 2003 the site was visited casually on seven days

8–14 September inclusive while the nest was active (incubation?), on several days thereafter, and on four days between 2 and 13 November (once at dusk).

In 2004 the nesting area was visited as follows, on 39 days between 23 August and 22 November. Observations, at intervals of several days, were spread over the latter half of incubation and the entire nestling period, as detailed below.

Incubation period: nine days, including three afternoons until dusk, three other afternoons until 0.5–1.75 h after sunset (4 h of darkness), and one morning from pre-dawn to sunrise (1.5 h of darkness); total 5.5 h of nocturnal observation.

Nestling period: 11 days, including three afternoons until dusk, three other afternoons until 2–3 h after sunset (7 h of darkness), one morning from pre-dawn to sunrise (2.5 h of darkness), and one all-night watch from dusk to sunrise (12 h); total 21.5 h of nocturnal observation.

Post-fledging period: almost daily (20 days) over the first month, including four afternoons until 0.5 h after sunset (total 2 h of darkness) and three mornings at dawn.

On the all-night watch there was an almost full moon with partial cloud cover. Nocturnal observations were assisted by a hand-held spotlight, which appeared not to affect the adults' behaviour. Dusk and nocturnal observations were made from an unconcealed position 55 m from the nest. In the early fledgling phase, dusk observations were curtailed when observer presence appeared to interfere with the Owl family's routines.

Twenty-three pellets (19 whole, four fragmented) and prey remains were collected in November 2002; 40 pellets (29 whole, 11 fragmented) and prey remains were collected in September–November 2003; and 138 pellets (79 whole, 59 fragmented) and prey remains were collected in August–October 2004. Most material from the adults was collected from below roosts within 10 m of the nest-tree, although some remains (feathers and bird legs) were found in a small area below a curved fallen log that rose 50 cm above the ground, apparently used as a plucking and feeding perch (12–15 m from the nest-tree). Pellets were also collected from beneath the owlets' various roost-sites.

Prey items were identified and quantified by ABR as described previously (Debus & Rose 2003), largely from ABR's reference collection of skulls, bones, feathers and insects. One prey item was also identified from a photograph of an adult Owl holding the item under its foot at the day roost, during the 2003 season. Insects were not included in calculations if they were inside the gut of Owl prey, e.g. one pellet contained a bird stomach-lining with remains of several insects, and a second pellet contained remains of the same bird with fine fragments of some of the same small insect species.

Results

Nest-sites

The 2002/03 nest-tree was situated on a gentle slope at the edge of a strip of riparian habitat, 30 m from a creek bed. The meandering creek varies from 5 to 10 m wide and for most of the year is a series of small waterholes, only flowing irregularly after rain, perhaps annually. Apart from this watercourse and other similar creeks within the State Forest, there are several farm dams on the fringes of the forest.

The trunk of the Owls' 2002/03 nest-tree, a 35-m, fairly sparsely foliaged Forest Red Gum *Eucalyptus tereticornis* (= Queensland Blue Gum), split into two main branches. The nest was in a short (10 cm) hollow spout angled at 50°, where one branch (30–40 cm in diameter) had broken off. The opening of the nest-hollow, ~25 m above the ground, was ~15 cm in diameter and faced north-east.

The 2004 nest-tree was another live Red Gum ~40 m tall and 4 m in circumference at the base, in the same riparian strip and <100 m from the 2002/03 nest. It was one of the largest trees in the immediate area, with sparse upper foliage as the top of the main trunk had been broken off. The nest-hollow was a spout coming off the main trunk at about 60°, ~30 m above the ground, and

with an entrance ~50 cm wide and facing west-north-west. The nest-hollow, which was partly obscured by foliage, appeared shallow, with the female's tail-tip visible on one occasion through a crack near the entrance as she tended the chicks.

In September 2004 a forestry mark appeared on a tree near the Owls' nest-tree, indicating an area planned for logging. Discussions with Forestry Department officers, during which they were shown the nest and roosting male, resulted in a buffer of 50+ m being placed around the nest-tree to prevent disturbance.

Breeding chronology

Back-dating from the fledging date of 17 November, using incubation and nestling periods of 5 weeks each (Higgins 1999), gave hatching in the second week of October and laying in the first week of September in 2002. Incubation appeared to be in progress in the first two weeks of September 2003. Hatching on 20 September put laying in mid August in 2004.

Roost-sites

In July 2004 the adults roosted in a Foambark *Jagera pseudorhus* 120 m from the nest-tree. During the breeding cycle, the adult(s) roosted in a variety of sites near the nest-tree. Trees used included Forest Red Gum, Pink Bloodwood *Corymbia intermedia*, Hickory Wattle *Acacia aulacocarpa*, Three-vein Cryptocaria *Melotis triplinervia*, Swamp Turpentine (= Swamp Mahogany) *Lophostemon suaveolens*, and figs *Ficus*.

The adults were not seen to roost side by side, but were sometimes in the same tree at different levels. Roosts varied from being in heavy foliage to fairly open perches shaded by foliage, at heights of 5–20 m. When not roosting close to the nest, the Owls tended to be in areas of denser vegetation, sometimes flushing before being seen.

Before the owlets fledged, the male's roost-sites were all within 10 m of the nest-tree. He roosted from 4 m above the ground (the least frequently used site) to 10–12 m high in a Swamp Turpentine, but more often in a Bloodwood, one of the taller trees in the area, at 25–30 m above the ground. The owlets roosted at various heights, once 3 m above the ground but usually 8–30 m above the ground; roost-trees along the creek were bushier and not as tall as those in the woodland.

Vocalisations

Terminology follows Higgins (1999) for the various call types given by the adult Barking Owls: *bark* (the disyllabic call), *growl*, *scream*, begging *trill* (also given by juveniles), and the low, prolonged *rumble* or 'groaning' *hoot* (the last two probably being variants of a single call type). This quavering, peevish call (here termed *hoot*) is deeper in the male than in the female. All of the various call types were sometimes heard during the day, in early to mid morning and late afternoon, according to circumstances (as described herein). In daylight, barking was quiet and subdued compared with the usual nocturnal duet by the adults.

The chicks' begging calls at ~8 days old were single *chip* notes given 3–4 times. Near the end of week 3 (night 19) they gave the cricket-like begging trills, almost continuously with breaks of <20 seconds between bouts.

Adult Barking Owl, Cordalba State Forest, Bundaberg, Qld

Plate 11 Photo: C.P. Barnes

Defensive behaviour

Early in the nestling period in 2004, the roosting male Barking Owl ignored a Pied Currawong *Strepera graculina* within 30 m of the Owls' nest, Noisy Friarbirds *Philemon corniculatus* and Little Lorikeets *Glossopsitta pusilla* near the nest-hollow, and a Brown Goshawk *Accipiter fasciatus* 50–100 m from the hollow. He also ignored two Currawongs while they mobbed him at his roost, then he shuffled/walked along the limb to a more protected perch. After dusk, the adults seemed to tolerate light (from the spotlight) on the hollow as they made feeding visits to the chicks. In week 4 of the nestling phase, as the adults roosted in separate trees, they called and answered with hoots perhaps in response to a nearby Currawong or to the observers. At the end of the nestling period four Noisy Friarbirds loudly mobbed the roosting female; she ignored them, but the male growled while watching the activity then barked after the Friarbirds left.

On the second morning post-fledging, the adults were roosting with an owlet low in a shrub. On approach by CPB the adults flushed and growled after alighting in separate trees. The adults made no further response while CPB collected food remains from the ground, but as CPB departed the male screamed several times and peered about, alert. The female also screamed as she returned to the owlet, which was trilling, then all became quiet.

Next morning, after sunrise and with the family of four roosting together in a tree, a Laughing Kookaburra *Dacelo novaeguineae* called and landed in a nearby tree; the female immediately chased it away. Later that week at dusk, as the family of Owls roused from their roost together in a tree, both adults growled as a

Currawong landed 50 m away. A Kookaburra then landed 50 m from the female, and she growled and chased it away. After both adults barked, the female noticed CPB seated on a stump; she growled, made short flights to different perches around CPB, then gave a single subdued scream, and the male also approached and growled.

Next evening, after dusk arousal, similar behaviour was repeated. The adults approached CPB (who was seated on a stump) and perched 10 m away. The owlets also approached and trilled, which seemed to inflame the situation as one adult remained near CPB while the other at first departed and barked distantly, but then returned.

The roosting adults were alert to Lace Monitors *Varanus varius*, which regularly scavenged under the roosts, and sometimes growled when they appeared. On a morning early in week 2 post-fledging, the roosting owlets trilled (possibly in agitation) as CPB arrived and flushed a Monitor, which began climbing a tree. An adult Owl growled, flew to an open perch and watched the lizard. As the lizard climbed higher, the male screamed, followed by the female, then both flew at the lizard, forcing it rapidly to the ground. At dusk that evening the adults flew over and growled at CPB, then followed and perched nearby as he retreated to a more distant viewing station.

At the end of week 2 post-fledging, in the morning, an adult gave a single short, soft hoot as a Currawong flew past within 5 m of the roosting family. The owlets also trilled as CPB searched under the tree. At the end of week 3, on two mornings, the roosting owlets again trilled as CPB arrived. Then, in mid morning, the roosting adult screamed and flew towards a tree outside the creek area, apparently at a potential predator.

2002 season

The adults were observed in the immediate vicinity of the nest between 5 July and 4 December 2002, with the nest first confirmed on 5 November 2002 (C. Moller pers. comm.). On 12 November 2002, two owlets were peering out of the nest at dusk, trilling. This call continued for several minutes, intensifying when one adult flew to the nest, before finally subsiding. Over 90 minutes passed before an adult again flew to the hollow, from low in the creek; no calls at the nest were audible. On a subsequent night, an adult visited the nest 12 times in 30 minutes (C. Moller pers. comm.). One owlet roosted out of the nest on 17 November, and both by 19 November. The fledged owlets shifted their daily roost-sites along the creek, with the adults, meaning that they became increasingly difficult to locate.

2003 season

In 2003 the adults appeared to re-use the 2002 nest-tree, but the breeding attempt terminated abruptly for unknown reasons early in the cycle (failed, perhaps raided by a monitor lizard). From 8 to 13 September one adult (presumed male) roosted in a tree in the nest area, and the other (presumed female) once hooted apparently from inside the hollow. Further visits failed to locate the birds by day. On 2 November at dusk, a soft 'sneeze' followed by an explosive *wow* (abrupt scream) emanated apparently from the pair's roost in dense vegetation, then both birds barked. On 3 and 5 November a single adult, with prey in its claws (possibly a plucked Laughing Kookaburra nestling in one instance), was found roosting in different areas along the creek; several pellets were found under one roost, but

there was no evidence of a stable roost or nest. On 13 November both adults were roosting near each other in another part of the creek, with no owlets.

2004: incubation period

The pair used a new nest-site in 2004. During the incubation period the male roosted within 10 m of the nest-tree, in a Bloodwood or Swamp Turpentine. Typically, at dusk, the male barked (and possibly hooted at times), and the female sometimes hooted from the hollow before emerging to perch and hoot or bark. If he had already departed, she flew from perch to perch, calling. The male sometimes barked during daylight, and the female occasionally hooted from within the hollow before dusk. On one night pre-dawn, the female hooted frequently (about every 5 minutes) from within the hollow as dawn approached, and barked once. The male arrived at 0515 h (~0.5 h before sunrise), and barked, growled and hooted before settling to roost.

Nestling period

In week 1, night 1 at dusk, the roosting male departed; 6 minutes later the female emerged from the hollow, barked from a perch and flew off. Within 10 minutes she returned with small prey (insect?) and took it straight into the hollow. Over the next 20 minutes she made four similar feeding visits. The male then arrived at the hollow entrance, the female trilled (in apparent food exchange) and both flew off. The female returned to the hollow twice then stayed in, hooting. The male barked then arrived at the hollow, and the female trilled and took food from his bill. Over the next 100 minutes she made 12 feeding trips into the nest with pieces of prey collected from the male, then stayed in the hollow.

Pre-dawn on night 4, all was quiet for the first hour (from 0315 h) then the female hooted from within the hollow irregularly, four times from 0430 h before the male arrived. He barked three times before the female responded with a low growl. He had prey in his bill and flew to a tree nearer the hollow at 0535 h, but by 0600 h he had eaten the food and was roosting.

Results from the all-night watch (Table 1) were probably typical for the pair's routines on a moonlit night early in week 2 of the nestling phase: male barking at dusk, female emerging to hoot (begging?) and duet (barking), then feeding visits to the nest soon after dusk and near midnight, with apparent foraging towards dawn. Later in week 2 (day 12), in late afternoon, the male flushed from his roost to a tree next to the hollow. He hooted, and the female hooted in reply from the hollow. At dusk he barked repeatedly, the female emerged and they barked in duet for several minutes until she went to another perch and hooted. The male left, and she continued to hoot for 3 minutes then left.

In week 3, day 15 the dusk routine was similar: the usual barking duet after the female emerged from the hollow, then female hooting before she departed in deepening dusk.

On day 19 the female roosted out of the hollow: the male in his usual Swamp Turpentine, the female higher in a Bloodwood. Around sunset the male barked, and at dusk the pair barked in duet, after which the female then the male hooted before he departed. She continued to call before also departing. Four brief feeding visits then followed over 10 minutes from 1825 h; on one of these, the adult paused and transferred small prey from foot to bill before flying into the hollow. The

Table 1

Results of an all-night watch at a Barking Owl's nest, Bundaberg, Qld, 27–28 September 2004: nestling period (week 2, day 8). Sunset at ~1745 h. M = male, F = female.

Time (h)	*Activity*
27 September	
1800 (dusk)	M barked from roost for 3 minutes before F appeared at hollow entrance and barked, flew to branch and hooted softly several times. M barked, F hooted then duet of barking; more M barking then more duet of barking.
1821	F left, M flew to hollow entrance then to branch; F returned, trilled (prey transfer?) then flew to nest.
1840	F hooted from within hollow, flew to dead tree (1857 h) and barked. M joined F on branch, both flew at 1905 h.
1907	F hooted from hollow, flew to bare branch (1913 h), returned to hollow at 1921 h.
2003	M returned, barked. F left hollow and joined M; F trilled, moved to another perch then returned to nest. M stayed until 2030 h, barked then glided into leafy eucalypt foliage at same level 30 m away, apparently caught prey (insect? by briefly brushing foliage). M barked, no response from F; M left at 2045 h.
2300–2325	F hooted softly twice. At 2350 h M arrived on bare branch, barked loudly. F arrived from hollow, landed ~50 cm from M and walked up branch to take mouse-sized prey, flew (to nest?). M barked loudly for a few minutes before leaving at 2400 h.
28 September	
0030	Chicks begging. F hooted softly at 0045 h.
0215	M? barked softly twice on bare branch; stayed 15 minutes then slipped away, not towards nest.
0410	M called, F approached him, then trilling calls. Both flew (not towards nest), in direction of noises of possible prey (possums?).
0447	M called from unseen perch.
0510	M called, settled to roost on tree by nest, barked many times. No response by F. Dawn approaching.

chicks' begging trills continued almost incessantly, with intermittent increases in fervour (though no action was visible), to 2005 h when they decreased and an adult was sitting at the hollow entrance. She (?) stayed for 5+ minutes before perching nearby and hooting. The chicks' trills had ceased, with no further calling until 2045 h (end of observations).

In week 4, day 22 at dusk (1755 h), the pair had roosted in separate trees. Male and female alternated hooting calls with barking duets. He then flew to her tree, and hooting continued until he departed at 1805 h. Similarly, on day 26 the male and female had roosted separately and at dusk they alternated hooting with barking. She walked along a branch, hooting while leaning forward, and he landed near her, without further interaction, before he departed at 1810 h. On day 31 they roosted in the same tree, ~3 m apart, but on day 35 they again roosted in separate trees.

The nestling period, from first indication of a hatchling on 20 September to fledging of the first owlet on about 26 October, was ~36 days. Fledging was asynchronous, the second owlet fledging on 28 October.

Photo: C.P. Barnes

Family of two adult and two fledgling Barking Owls, Cordalba State Forest, Bundaberg, Qld, October 2004

Plate 12

Fledgling Barking Owl, Cordalba State Forest, Bundaberg, Qld, October 2004

Plate 13 Photo: C.P. Barnes

Post-fledging period

One fledgling was out of the nest on 27 October, but may have fledged a day or two earlier, judging by the appearance of whitewash under the fledgling's roost. On 27 October (taken as day 2), the owlet roosted 5 m above the ground in a wattle, guarded by the adults which also roosted low near or with it. On day 3 the adults and two owlets roosted together in a Swamp Turpentine, within a few metres of each other, 10–12 m above the ground. All were irritated by horse-flies (Tabanidae) at their feet, responding by snapping at them and shuffling their feet. The younger owlet rested with its chin on the branch at 1020 h. From day 4 to the end of week 3 the family usually roosted together in various sites in the nest area, sometimes high in eucalypts but also low in creekside trees, at times over water (Table 2). At dusk in weeks 1–2 the adults barked, sometimes in duet, and the owlets begged and followed the adults.

By the start of week 4 it became increasingly difficult to locate the Owls during the day. Although they called at dusk, their roost was not found. At 4 weeks post-fledging the family appeared to have moved away from the nest area, but the owlets were (by their trills and behaviour) still dependent until at least day 27. On 31 January 2005 (3 months post-fledging) there was no sign of the Owls, or their pellets or whitewash, in the nest area.

Table 2

Behaviour of Barking Owl family in post-fledging period, Bundaberg, Qld, October–November 2004. Sunset initially at ~1800 h. Week/day = stage of period; M = male, F = female.

Week/day	*Time*	*Activity*
1/4	Day	Owlets roosted high next to each other, adults nearby.
1/5	Day	All four roosted high in Bloodwood, one owlet with the adults and the other 4 m away. Younger owlet briefly lay on branch.
1/6	Day	All four roosted together high in Bloodwood. Owlet briefly lay on branch.
1/7	Day	Owlets next to each other in Bloodwood, adults nearby in same tree.
	Dusk	Quiet until 1800 h, then owlets gave intermittent trills and became much more animated. Calls ignored by adults initially. Owlets increased intensity/frequency of trill, walked along branch, swayed from side to side and bobbed heads; sometimes opened wings or stretched them over their heads. Adults barked briefly. Owlets made short flights to nearby branches; older one better at flying, younger made shorter flights, opened wings to steady on landing.
2/8	Day	F next to one owlet, M 5 m away, other owlet nearby, all in large Bloodwood. Owlets trilled at 1745 h when three White-throated Honeyeaters *Melithreptus albogularis* congregated and called around Owls; ignored by adults.
	Dusk	Young more vocal at 1805 h, repeated previous evening's behaviour (clambering, short flights, spreading and arching wings, begging with gyrating head). One owlet nibbled and pulled at foliage. Owlets briefly bill-touched and allopreened back and tail. Adult barking duet, F flew to another perch and joined by M, followed by owlets which increased intensity of trilling and body movements.
2/10	Day	New roost-site in creekline; owlets perched near each other (1–2 m apart), adults hidden.
	Dusk	Owlets now apart, M nearby, F slightly farther away. Owlets trilling intensely and winding heads, swaying bodies.
2/11–14	Day	Owlets and one or both adults roosting in tall Bloodwood, Swamp Turpentine, or Turpentine next to nest-tree.
3/15–21	Day	Owlets and one or both adults roosting in Turpentine next to nest-tree, high in Bloodwood, in other Turpentine, or (on hot day, 34°C), in tree in creek, perched over water.
4/22	Day	All in tree in creek, roosting over water.
4/23	Day	Owls not in usual sites around nest-tree; not seen or heard in 100 m of creekline.
4/27	Day	Owls not found, few food remains under roosts.
	Dusk	Owlets trilled and adults barked briefly >50 m from nest-tree.
4/28	Day	Owls not found on either side of creek or in side tributaries; no calls or whitewash evident

Table 3

Breeding diet of a pair of Barking Owls and young, Cordalba State Forest, Bundaberg, Qld, November 2002, November 2003 and August–October 2004, from pellets (n = 23 in 2002, 40 in 2003, 138 in 2004) and prey remains. Minimum number of prey individuals by skull count, teeth and insect heads. Prey weights from Strahan (1995), Higgins (1999) and related volumes and other literature, or estimated.

Prey species	*Weight (g)*	*2002*	*2003*	*2004*	*Total*
Sugar Glider *Petaurus breviceps*	128	3	9	12	24
Squirrel Glider *Petaurus norfolcensis*	230	3	8	22	33
Feathertail Glider *Acrobates pygmaeus*	12		1		1
Little Red Flying-fox *Pteropus scapulatus*	448			1	1
Bat (Microchiroptera)	10		1	1	2
Total mammals		**6**	**19**	**36**	**61**
Little Bittern *Ixobrychus minutus*	84	1			1
Lewin's Rail *Rallus pectoralis*	78		1		1
Scaly-breasted Lorikeet *Trichoglossus chlorolepidotus*	87	1			1
Pale-headed Rosella *Platycercus adscitus*	112	1	1		2
Tawny Frogmouth *Podargus strigoides*	326	1			1
feathered nestling	150			1	1
White-throated Needletail *Hirundapus caudacutus* (immature)	98			1	1
Noisy Friarbird *Philemon corniculatus*	101	1		1	2
Noisy Miner *Manorina melanocephala*	56	1		1	2
Lewin's Honeyeater *Meliphaga lewinii*	33	1			1
Black-faced Cuckoo-shrike *Coracina novaehollandiae*	105	1			1
Grey Butcherbird *Cracticus torquatus*	85			1	1
Australian Magpie *Gymnorhina tibicen*	314	1	1	1	3
Torresian Crow *Corvus orru*	558	1			1
Thrush *Zoothera* sp.	100			1	1
Unidentified bird	152[a]	2	1		3
Nestling bird	20		1		1
Total birds		**12**	**5**	**7**	**24**
Huntsman spider (Heteropodidae)	1			1	1
Beetles (Coleoptera)	1			16	16
Ground-beetle (Carabidae)	1	1		2	3
Weevil (Curculionidae)	1	1			1
Longicorn beetle (Cerambycidae)	1		1	1	2
Prioninae	1	8			8
Phoracantha sp.	1	1	1	11	13
Click beetle (Elateridae)	1	1		1	2
Christmas beetle *Anoplognathus* sp.	1			1	1
Black Beetle *Heteronychus arator*	1			2	2
Other scarabs (Scarabeidae)	1	7	12	5	24
Melolonthinae	1			44	44
Dynastinae	1	1	10		11
Scarabaeinae	1		2	2	4
Cockroach (Blattodea)	1			1	1
Moth (Lepidoptera)	1			1	1
Stick insect (Phasmatidae)	1			1	1
Grasshopper (Orthoptera)	1	3	16	2	21
Total arthropods		**23**	**42**	**91**	**156**
Total prey items		**41**	**66**	**134**	**241**

[a]Mean of identified birds

Diet

Forty-eight intact pellets from 2002 and 2003 averaged 37 × 21 mm (23–55 × 17–30 mm). In 2004, 79 intact pellets averaged 37 × 23 mm (18–60 × 15–30 mm). By number, the Owls' breeding diet consisted of 25% mammals, 10% birds and 65% arthropods for all three years combined (Table 3). However, by biomass the diet consisted of 74% mammals, 24% birds and 1% arthropods (from Table 3).

All mammals taken were arboreal or aerial native species. Collectively, the Sugar Glider *Petaurus breviceps* and Squirrel Glider *P. norfolcensis* contributed 71% of prey biomass. These species occurred, separately, in 105 (52%) and 64 (32%) of 201 pellets respectively; 86% of pellets contained one or the other (including unidentified *Petaurus*).

Birds occurred in 26 pellets (13%), mostly as feather and bone fragments, but were also represented by loose feathers at the Owls' nest. Birds contributing substantial dietary biomass were parrots and large species (Tawny Frogmouth *Podargus strigoides*, Australian Magpie *Gymnorhina tibicen* and Torresian Crow *Corvus orru*), collectively 15% of total biomass or 62% of avian biomass (from Table 3).

Arthropods occurred in 111 pellets (55%), mostly in small numbers (1–3 individuals). However, three pellets contained five, seven and eight beetles respectively.

There was some inter-year difference in the relative contribution of mammals and birds. In 2002 the Owls' diet was 15% mammals and 29% birds by number, or 34% and 65% respectively by biomass; in 2003 it was 29% mammals and 8% birds by number, or 81% and 18% respectively by biomass; and in 2004 it was 27% mammals and 5% birds by number, or 88% and 11% respectively by biomass. Arthropods contributed 56–68% by number and 1% by biomass in all three years.

Two pellets in one sample contained 12 small insects, including an ant, that were assumed to have been the prey of a bird represented in the same two pellets, as its stomach-lining was in one pellet. If included, these items do not affect the biomass contribution of insects to the Owls' diet.

Discussion

This study extends previous knowledge of the Barking Owl's breeding behaviour from dusk to early evening, through moonlit nights and before dawn, but the difficulty is to observe the Owls in full darkness. Behaviour in partial nocturnal light may not be typical of darker nights, and observer presence may also affect the adults' behaviour in the early fledgling phase, when they may defend rather than feed owlets. Nevertheless, the adults' dusk routines in the incubation and nestling phases may be typical for the species, as may the family's daily routines in the post-fledging period. It appeared that the female made frequent visits, with insect prey, to the nestlings at dusk while awaiting the male's delivery of larger prey, and that he made occasional visits with prey through the night.

Asynchronous fledging, by ~2 days, is consistent with laying at intervals of 2–3 days and incubation starting with the first egg. The female first roosted outside the hollow in week 3 of the nestling phase, and the shrub layer was evidently important as refuge for newly fledged owlets. These aspects, a nestling period of ~36 days, and the owlets' post-fledging behaviour, are all consistent with previous knowledge of the Barking Owl or other *Ninox* owls (reviewed by Higgins 1999).

The post-fledging dependence period was not determined beyond the first month, but Debus *et al.* (2005) found one juvenile still partly dependent, though catching insects, at 5 months post-fledging. This value is intermediate between that for the larger Powerful Owl *Ninox strenua* and smaller Southern Boobook *N. novaeseelandiae* (Higgins 1999), and may be realistic though confirmation is required.

Parental defence against potential nest predators (including observers) was not seen during the incubation phase and was minimal during the nestling phase, but increased greatly in the fledgling phase. The scream was previously thought to be seldom heard during the breeding season (Higgins 1999), but is sometimes used in defence of fledglings. Human presence may have increased the amount of daytime calling by the adults.

The results of this study are similar to those of other dietary studies in coastal or temperate south-eastern Australia (Higgins 1999 and references therein; Debus 2001; Taylor *et al.* 2002b; Debus *et al.* 2005), and substantially expand the dietary sample of Hodgon (1996) for the present study site. This study, as for most previous ones, found a fairly high (though annually variable) proportion of birds in the Owl's diet, and supports the impression that the Owl is an opportunistic hunter. The nocturnal or crepuscular aquatic birds taken (Little Bittern *Ixobrychus minutus*, Lewin's Rail *Rallus pectoralis*) are novel prey species for the Barking Owl, and reinforce the apparent association of the Owl with wetland margins (Higgins 1999; Taylor *et al.* 2002a; Debus *et al.* 2005). The White-throated Needletail *Hirundapus caudacutus*, noteworthy prey for an owl, was probably taken while roosting in foliage (Higgins 1999). Most of the Owls' avian prey at Cordalba are diurnal and were probably caught at dusk or while roosting (cf. Higgins 1999 for other *Ninox* species), although *Zoothera* thrushes are crepuscular (SD pers. obs.) and may be caught while active in semi-darkness.

Like many previous studies, this study also reinforces the importance of arboreal marsupials in the Barking Owl's breeding diet. Although by number insects can contribute a high proportion of the dietary total, it is apparent that they contribute a minuscule proportion to dietary biomass, and that the Owl is heavily dependent on vertebrate prey (especially gliding possums *Petaurus*) during its breeding cycle. The Squirrel Glider, at nearly twice the weight of the Sugar Glider and contributing more than twice the total dietary biomass (51% versus 21% at Cordalba), may be an ideally sized, key prey species of the Owl in eastern Australia. In pre-myxomatosis and pre-calicivirus times, Rabbits *Oryctolagus cuniculus* were frequent prey of Barking Owls in certain areas (Higgins 1999), but arboreal mammals are apparently preferred (Debus 2001; Debus *et al.* 2005).

We speculate that at Cordalba later laying in 2002 was associated with shortage of mammalian prey (reflected in the high proportion of birds in the Owls' diet), and earlier laying in 2004 with abundant mammalian prey. Mammals may be the more rewarding prey type, enabling female Owls to reach breeding condition early in the season. In other owl species, early laying associated with abundant mammalian prey has later benefits for breeding success, fledging weight and juvenile survival to recruitment (Taylor 1994; Marks *et al.* 1999).

The results for Cordalba suggest what the Barking Owl's diet may have been like in the temperate woodlands before extensive clearance and fragmentation of its habitat. It is apparent that the Owl's major prey species are dependent on mature woodland with hollows, and on other habitat attributes that support high densities of small and medium-sized gliders. Barking Owl territories are associated

with rich woodland types, hollows and arboreal marsupials (Milledge 2004). The rarity and decline of the Squirrel Glider in the wheat belt (Strahan 1995) may help to explain the decline of the Barking Owl, and its apparent dependence on hydrological features where aquatic birds may partly substitute for now-scarce mammalian prey (Taylor *et al.* 2002a,b; Debus *et al.* 2005).

Given the Barking Owl's apparent preference for arboreal mammals of ~200 g, the extinct White-footed Tree-Rat *Conilurus albipes* (~200 g) and threatened Tuan *Phascogale tapoatafa* (mean 194 g) may also have been prey species in the temperate woodlands (cf. Strahan 1995). Terrestrial native rats ~100 g are frequent prey in the arid subtropics (Debus & Rose 2003). Dietary data collected for the Barking Owl in the tropics (CSIRO 1982), but as yet unpublished, would be instructive.

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